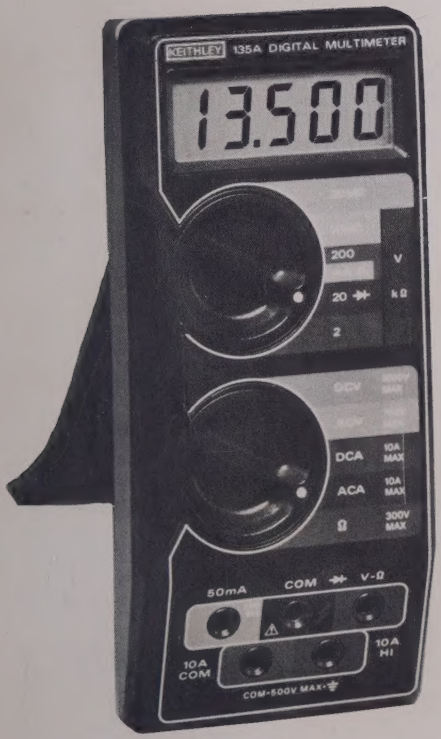
KEITHLEY

Model 135A
Digital Multimeter



Publication Date: November 1984
Document Number: 135A-901-01D

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace, at our option, any instrument or part thereof which, within a year from date of shipment, proves defective upon examination. We will pay local domestic surface freight costs. (NOTE: This warranty does not cover battery replacement or damage due to battery leakage.)

SERVICE POLICY

For service on your Model 135A Digital Multimeter, contact your local Keithley representative who will be able to give you immediate assistance in most cases. Complete repair and calibration facitilites are maintained in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland, and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of the above locations. (Addresses are located on the back cover.)

SAFETY SYMBOLS AND TERMS

The symbol on the instrument denotes that the user should refer to the operating instructions.

The symbol on the instrument denotes that 100V or more may be present on the terminals.

The **WARNING** used in this manual explains dangers that could result in personal injury or death.

The **CAUTION** used in this manual explains hazards that could damage the instrument.

SPECIFICATIONS

DC VOLTS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg + digits)/°C 0°-18°C & 28°-50°C
2 V	100 μV	0.05% + 1d	0.012% + 0.3d
20 V	1mV	0.05% + 1d	0.012% + 0.3d
200 V	10mV	0.1 % + 1d	0.012% + 0.3d
1000 V	100mV	0.1 % + 1d	0.012% + 0.3d

INPUT RESISTANCE: 10MΩ.

NORMAL MODE REJECTION RATIO: Greater than 60dB @ 50Hz, 60Hz.

COMMON MODE REJECTION RATIO (1kΩ unbalance): Greater than 120dB @ DC, 50Hz & 60Hz.

MAXIMUM ALLOWABLE INPUT: 1000V DC or peak AC non-switched, 750V peak switched.

AC VOLTS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C
2 V	100 μV	1% + 15d, 45Hz- 10kHz*
20 V	1mV	1% + 15d, 45Hz-500 Hz
200 V	10mV	1% + 15d, 45Hz-120 Hz
750 V	100mV	1% + 15d, 45Hz-120 Hz

*Above 2000 counts.

Extended range accuracy: 5% + 15d, 10kHz-20kHz

RESPONSE: Average responding, calibrated in rms of a sine wave.

INPUT IMPEDANCE: 10MΩ shunted by less than 100pF.

COMMON MODE REJECTION RATIO (1kΩ unbalance): Greater than 60dB @ DC, 50Hz & 60Hz.

MAXIMUM ALLOWABLE INPUT: 750V rms, 1000V peak continuous on 20V, 200V, 750V ranges, 10^6V•Hz max ; 300V rms continuous, 750V momentary (3 seconds) on 2V range

TEMPERATURE COEFFICIENT: Less than (0.1 × applicable accuracy)/°C (0°-28°C & 35°-50°C).

OHMS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg + digits)/°C 0°-18°C & 28°-50°C	MAXIMUM TEST CURRENT
2 kΩ	100mΩ	0.25% + 5d	0.05% + 0.3d	−750 μA
20 kΩ	1 Ω	0.2 % + 2d	0.01% + 0.5d	−150 μA
200 kΩ	10 Ω	0.2 % + 2d	0.01% + 0.5d	− 15 μA
2000 kΩ	100 Ω	0.2 % + 2d	0.01% + 0.5d	− 1.5 μA
20MΩ	1 kΩ	1 % + 2d	0.1 % + 0.5d	− 0.15μA

MAXIMUM FULL SCALE VOLTAGE: −1V.

MAXIMUM OPEN CIRCUIT VOLTAGE: −2V.

OVERLOAD PROTECTION: 300V DC or rms on all ranges.

DIODE TEST: On-scale reading for forward biased silicon diode.

DC AMPS

RANGE	RESOLUTION	ACCURACY (1 YEAR) ±(%rdg + digits) 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg + digits)/°C 0°-18°C & 28°-50°C	MAXIMUM VOLTAGE BURDEN
50mA	10 μA	0.25% + 2d	0.05% + 0.3d	0.6V
10 A	10mA	1 % + 2d	0.05% + 0.3d	0.3V

OVERLOAD PROTECTION: 50mA input: 0.75A fuse (250V), externally accessible. **10A input:** 20A for 15s unfused.

AC AMPS

RANGE	RESOLUTION	ACCURACY (1 YEAR) 45Hz-1kHz ±(%rdg + digits) 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg + digits)/°C 0°-18°C & 28°-50°C
50mA	10 μA	1.5% + 5d	0.15% + 0.5d
10 A	10mA	1.5% + 5d	0.15% + 0.5d

OVERLOAD PROTECTION: 50mA input: 0.75A fuse (250V), externally accessible. **10A input:** 20A for 15s unfused.

GENERAL

DISPLAY: 4½-digit LCD, 0.6" height, polarity and range indication, low battery warning.

CONVERSION PERIOD: 400ms (2.5 readings/second).

OVERRANGE INDICATION: 4 least significant digits blanked.

MAXIMUM COMMON MODE VOLTAGE: 500V DC or peak AC.

OPERATING ENVIRONMENT: 0° to 50°C; less than 80% relative humidity up to 35°C; linearly derate 3% RH/°C, 35° to 50°C.

STORAGE ENVIRONMENT: −35°C to 60°C, less than 90% relative humidity up to 35°C; linearly derate 3% RH/°C, 35°C to 60°C.

POWER: One 9V alkaline or carbon-zinc battery (NEDA 1604).

BATTERY LIFE: 100 hours typical with alkaline battery; 50 hours typical with carbon-zinc battery.

BATTERY INDICATOR: Display indicates "BAT" when less than 10% of life remains.

DIMENSIONS, WEIGHT: 178mm long × 78mm wide × 42mm thick (7.0" × 3.1" × 1.6"). Net weight 400gm (14.1 oz.).

ACCESSORIES SUPPLIED: Battery, instruction manual, Model 1691 Test Lead Set.

Specifications subject to change without notice.

GENERAL INFORMATION

The Model 135A is a 4½ digit handheld DMM. The 20,000 count liquid crystal display permits greater resolution than the usual 3½ DMM. Full five function capability of DCV, ACV, DCA, ACA and OHMS allows the user wide versatility.

UNPACKING AND INSPECTION

The Model 135A is inspected both mechanically and electrically before shipment. Upon receiving the Model 135A unpack all items from the shipping container and check for any obvious damage that may have occurred during transit. Report any damage to the shipping agent. Retain and use the original packaging materials if reshipment is necessary. The following items are shipped with all Model 135A orders:

Model 135A Digital Multimeter
Instruction Manual (135A-901-01A)
9V Battery (BA-14)
Model 1691 Test Lead Set
Optional Accessories per request.

MANUAL ADDENDA

Improvements or changes to this manual will be explained on an addendum included with this manual.

OPTIONAL ACCESSORIES

Model 1600A High Voltage Probe extends the DMM measuring capability to 40kV. It has a 1000:1 division ratio which means that 1 volt on the DMM corresponds to 1kV.

Model 1651 50 Ampere Shunt allows current measurements to be made from 0 to 50 amperes DC and from 10 to 50 amperes AC. It is a 0.001 ohm ±1% 4-terminal shunt. A 50 ampere current will correspond to 50 millivolts.

Model 1681 Clip-On Test Lead Set contains two leads 1.2m (48 inches) long that are terminated with banana plug and spring-action clip-on probes.

Model 1682A RF Probe allows voltage measurements from 100kHz to 250MHz.

Model 1683 Universal Test Lead Kit includes two test leads, 1.2m (48 inches) long with 12 screw-in tips, 2 banana plugs, 2 spade lugs, 2 alligator clips with boots, 2 needle tips with chucks and 4 heavy duty tip plugs.

Model 1685 Clamp-On AC Current Probe measures AC current by clamping onto a single conductor. Interruption of the current path is unnecessary. The Model 1685 detects current by sensing the magnetic field produced by the current flow. To operate, set the DMM to ACV and the appropriate range. The DMM will display 0.1V RMS per ampere.

Model 1301 Temperature Probe measures temperature from -55°C to +150°C . The probe can be used with any Keithley DMM that has at least 10MΩ input impedance. The output of the probe corresponds to 1mV/°C.

Model 1304 Soft Carrying Case and Stand (tilt bail) for Keithley's line of handheld instruments. The instrument can be secured inside the case with the thumbscrew (supplied), if desired. The thumbscrew is also used to secure the stand (tilt bail) to set the instrument upright.

Model 1306 Deluxe Carrying Case is a rugged DMM carrying case that is large enough to accomodate the Model 135A plus various other DMM articles such as a spare battery, test leads, etc.

Model 1691 General Purpose Test Lead Set Consists of two 0.9m (36in) test leads with probe tips only. Banana connection to meter.

SAFETY PRECAUTIONS

1. Do not exceed the instrument's maximum allowable inputs as defined in the specifications.
2. Do not apply more than 500V peak above earth ground to the COM input jack.
3. Exercise extreme caution when a shock hazard is present at its input. The American National Safety Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS or 42.4V peak are present.
4. A good safety practice is to expect that hazardous voltages are present in any unknown circuit to be measured, until actual conditions are verified.
5. The battery and fuse are accessible from the bottom of the instrument. Note the precautions on the case before installing or replacing either.

OPERATION

This section gives step by step procedures to operate the Model 135A. Environmental conditions and preparation for use information is also provided.

PREPARATION FOR USE

1. Install fresh battery (Keithley Part Number BA-14). See Servicing Information section.
2. Check current fuse continuity.
   A. Select Ω and the 2kΩ range.
   B. Connect a jumper wire from the V-Ω jack to the 50mA jack.
   C. The display should read approximately .0100 ±20%. An overranged display indicates a blown fuse. A display reading other than approximately .0100 could indicate a defective current input circuit (see schematic).
3. The Model 135A should be placed in the environmetal conditions described in the following paragraph for at least one hour. The instrument does not have to be on for this period.

ENVIRONMENTAL CONDITIONS

All measurements should be made at an ambient temperature within the range of 0°C to 50°C. Up to 35°C at less than 80% relative humidity. And 35°C to 50°C derate 3% RH/°C. Refer to the specifications.

Operating Instructions

Basic operation is shown on page 4.

Diode Test

The Model 135A can be used to test semiconductor junctions. Use the following procedure:

1. Select Ω and the 20kΩ range. The diode symbol next to the 20 is a reminder that the test should be done on this range.
2. With the diode forward biased (anode connected to COM and cathode connected to V-Ω) an on range reading indicates the diode is probably good. An overrange display indicates the diode is open.
3. With the diode reversed biased (anode connected to V-Ω and the cathode connected to COM) an overrange reading indicates the diode is probably good.

WARNING

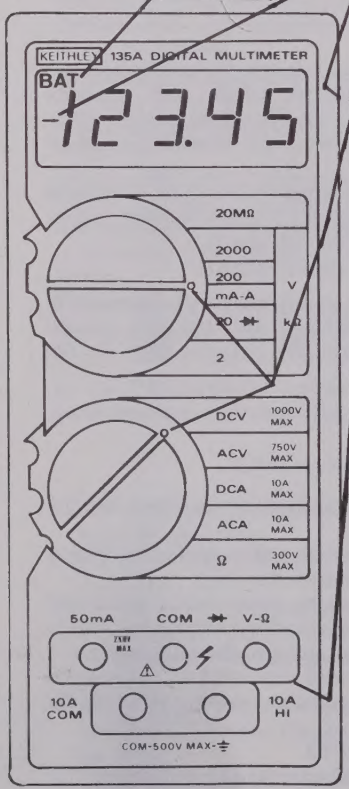
When measuring AC or DC current, do not make measurements in circuits where the open circuit voltage is greater than 250V.

CAUTION

Do not exceed the maximum allowable input. Instrument damage may occur. The maximum allowable input is stated in the specifications.

NOTE

An overrange condition is indicated by a "1" followed by a blank display.



1. SET POWER ON.
   The power switch is located on the side of the Model 135A.
2. SELECT DESIRED FUNCTION AND RANGE.

Function	Ranges	Maximum Input
DCV	2V, 20V, 200V or 1000V	1000VDC
ACV	2V, 20V, 200V or 750V	750V rms
DCA	mA-A	0.75A (fused)
ACA	mA-A	0.75A (fused)
Ω	2k, 20k, 200k, 2000k or 20M	300V

3. SELECT APPROPRIATE PAIR OF INPUT JACKS
   a. V-Ω and COM are used for all voltage and resistance measurements.
   b. 50mA and COM are used for AC and DC current measurements on the 50mA range.
   c. 10A HI and 10A COM are used for AC and DC current measurements on the 10A range.
4. MAKE THE MEASUREMENT
   a. Touch the probes to the signal that is to be measured. Observe proper polarity.
   b. Make the measurement by reading the display.

SERVICING INFORMATION

VERIFICATION PROCEDURE

Performance verification can be performed upon receipt of the instrument to ensure that no damage or misadjustment has occurred during transit. Verification may also be performed whenever there is question of the instruments accuracy and following calibration, if desired.

Table 1. Recommended Test Equipment

Item	Description	Specification	Mfr.	Model
A	DC Calibrator	0.1V, 1V, 10V, 100V, 1000V ±0.002% or 2μV	Fluke	343A
B	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	Fluke	5200A
C	AC Calibrator/ Amplifier	1000V @ ±0.04%	Fluke	5215A
D	Decade Resistor	1.9kΩ, 19kΩ, 190kΩ 1.9MΩ, 19MΩ, ±0.01%	ESI	RS725
E	Current Calibrator	50mA, 10A	Valhalla	2500E

Environmental Conditions

Measurements should be made at 18°C to 28°C with less than 80% noncondensing relative humidity.

Use the following tables to verify the performance of the Model 135A. Apply the specified input to the appropriate input jacks. Verify that the readings are within the limits specified in the tables.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

CAUTION

Do not exceed the maximum allowable input for any given range. Instrument damage may occur. The maximum allowable inputs are stated in the specifications.

Table 2. DCV Verification

Range	Applied Input	Allowance Reading at 18°C to 28°C
2V	1.9000V	1.8989 to 1.9011
20V	19.000V	18.989 to 19.011
200V	190.00V	189.80 to 190.20
1000V	1000.0V	998.9 to 1001.1

Table 3. ACV Verification

Range	Applied Input	Allowance Reading at 18°C to 28°C
2V	1.9000V at 1kHz	1.8795 to 1.9205
20V	19.000V at 500Hz	18.795 to 19.205
200V	190.00V at 120Hz	187.95 to 192.05
750V*	750.0V at 120Hz	741.0 to 759.0

*Model 5200A requires the Model 5215A High Voltage Amplifier (Item C, Table 1) to obtain the 750V.

Table 4. DCA Verification

Range	Applied Input	Allowance Reading at 18°C to 28°C
50mA	50.00mA	49.85 to 50.15
10A	10.00A	9.88 to 10.12

Table 5. ACA Verification

Range	Applied Input	Allowable Reading at 18°C to 28°C
50mA	50.00mA to 500Hz	49.20 to 50.80
10A	10.00A at 500Hz	9.80 to 10.20

Table 6. OHMS Verification

Range	Applied Input	Allowable Reading at 18°C to 28°C
2k	1.9000kΩ	1.8947 to 1.9053
20k	19.000kΩ	18.960 to 19.040
200k	190.00kΩ	189.60 to 190.40
2000k	1900.0kΩ	1896.0 to 1904.0
20M	19.000MΩ	18.808 to 19.192

THEORY OF OPERATION

While studying the theory of operation it will be helpful to refer to the schematic diagram 135A-106.

Signal Conditioning

DC Volts: R101 and R102 attenuate the DCV input signal to a ±2V full scale input for the A/D converter.

AC Volts: Attenuation is accomplished by R101 and R102.

The AC to DC converter is comprised of U102 and its associated circuitry. R110 along with R111 through R113 provide the gain required to convert from the rectified waveform average to the RMS of a sine equivalent. C104, C105 and C106 provide close loop stability for U102.

DC Amps: R103 is a 10Ω shunt for the 50mA range while R104 is a 0.01Ω (4-terminal) shunt for the 10A range. Range selection is provided by selection of the appropriate input jacks. CR101 protects shunt resistor R103 by clamping the burden voltage to approximately 2V.

AC Amps: The ranges and range selection is identical to DC amps. The only difference is the sensed voltage for AC amps is conditioned by the AC to DC converter before going to the A/D converter.

OHMS: During ohms the COM input is switched to the ohms source (1.23V nominal) along with IN LO of the A/D converter. The voltage converted by the A/D is developed across the unknown resistance that is being measured. The reference voltage for the A/D is developed across the reference resistor (R101 and/or R102).

RT101 is a positive temperature coefficient thermistor that limits the current through Q101.

Ohms Detector: The ohms detector (U103) and exclusive OR gate (U105A) are configured to detect the polarity of the COM input and invert the sign on the display in all functions except ohms.

Analog to Digital Converter (A/D)

The analog to digital converter operates on measurement cycles that have four distinct phases for each cycle.

Auto-Zero Phase: During the auto zero phase, three steps take place.

1. Inputs HIGH and LO (IN HI and IN LO) are disconnected from the pins and is internally shorted to analog common.
2. The reference capacitor (C207) is charged to the reference voltage.
3. A feedback loop is closed around the system to charge the auto zero capacitor C209.

Signal Integrate Phase: During the signal integrate phase, the auto zero loop is opened, the internal shorts are removed and the internal IN HI and IN LO are connected to the external pins. The converter then integrates the differential voltage between IN HI and IN LO for 100msec.

Reference Integrate (De-integrate) Phase: IN LO is internally connected to analog common and IN HI is connected across the previously charged reference capacitor (C207). Circuitry within U201 ensures that the capacitor is connected with the correct polarity to cause the integrator output to return to zero. The time required for the output to return zero is proportional to the input signal.

Zero Integrate Phase: In the final phase of the measurement cycle, IN LO is shorted to analog common. Then the feedback loop is closed around the system to IN HI to cause the integrator output to return to zero. Generally, this phase lasts from 10msec to 20msec.

After the zero integrate phase the entire cycle with each of the four phases starts over again. Each measurement cycle is 400msec long.

Display and Interface

U201 is a 4½ digit converter designed to drive LED displays. U202, U203, U204, U205 and U107 comprise the circuitry to interface the A/D to the LCD display.

The backplane is generated by U107. The backplane is a low frequency (approximately 125Hz) square wave. When a display segment is off, the segment drive waveform is in phase with the backplane. If the segment is on, the segment drive waveform is 180° out of phase with the backplane.

Power Supply and Reference Circuit

The analog and digital supply regulation is accomplished by U206A and its associated components. The regulated +5V supply powers CR201. The voltage generated by CR201 is used to derive the +5V supply. The regulated +5V supply is applied to U207 which is a high efficiency power converter generating -5V. U207 generates the -5V by charging C203 to +5V and then switching the positive lead of C203 to ground and charging C204 to -5V.

CR201 is used to derive the 1.0000V reference. Its voltage is attenuated by R201, R203 and R204.

Clock

Y201 is the heart of the master clock of the Model 135A. Y201 is a 200kHz ceramic resonator, and along with U203A, form the oscillator of the clock. The output of the oscillator is applied to U202A, which divides the clock frequence by two.

CALIBRATION

Recommended Calibration Equipment

Model 135A recommended calibration equipment is listed in Table 7. If alternate equipment is used, the alternate equipment specifications must be at least as good as the equipment specifications listed in Table 7.

Table 7. Recommended Calibration Equipment

Item	Description	Specification	Mfr.	Model
A	DC Calibrator	1.90000V, 19.0000V ±0.002%	Fluke	343A
B	AC Calibrator	1.00000V at 1kHz ±0.022%	Fluke	5200A

Environmental Conditions

Calibration should be performed at an ambient temperature of 18°C to 28°C at less than 80% relative humidity. Before beginning the calibration procedure the Model 135A should meet the following conditions.

If the instrument has been subjected to temperature extremes, allow internal temperatures to stabilize for one hour minimum at the environmental conditions specified in the previous paragraph. Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of the specified temperature range.

Calibration Procedure

1. Select the DCV function.
2. Select the 2V range.
3. Apply +1.90000V to the V-Ω and COM terminals.
4. Adjust R202 (see Figure 2) for a display readng of 1.9000 ± 1/2 digit.
5. Select the 20V range.
6. Apply +19.0000V to the V-Ω and COM terminals.
7. Adjust R101 (see Figure 2) for a display reading of 19.000 ± 1/2 digit.
8. Disconnect the DCV calibrator and connect the ACV calibrator to the V-Ω and COM terminals.
9. Select the ACV function.
10. Select the 2V range.
11. Apply 1.00000VAC at 1kHz to the V-Ω and COM terminals.
12. Adjust R110 (see Figure 2) for a display reading of 1.0000 ± 1/2 digit.
13. The calibration sequence is now complete.

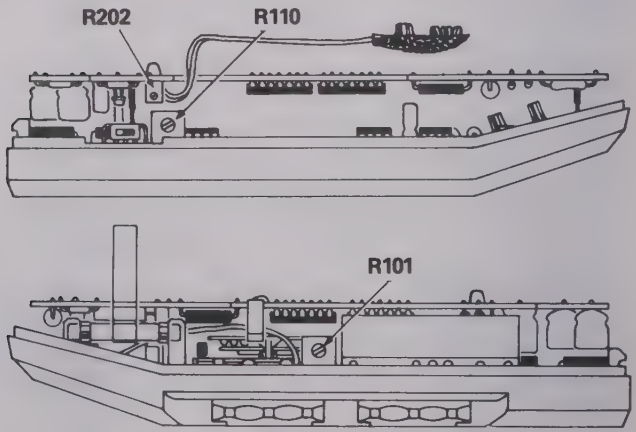


Figure 2. Calibration Adjustments

Battery and Fuse Replacement

A 9 volt battery is supplied with the instrument but is not installed. To install or replace the battery, remove the cover from the battery compartment by sliding it off in the direction of the arrow located on the battery cover.

WARNING

Disconnect the test leads and turn the instrument off before replacing the battery or the fuse. Reinstall the covers before resuming use of the instrument.

The battery connector snaps on and off the terminal of the battery. Improper installation of the battery may cause the connecting wires to be severed by excess strain. Proper installation requires that the battery be positioned in such a manner (refer to Figure 3) that the leads protruding from the boot of the battery connector face toward the outside of the battery compartment. If the instrument is going to be stored for a long period of time or in a high temperature environment, remove the battery to prevent leakage damage.

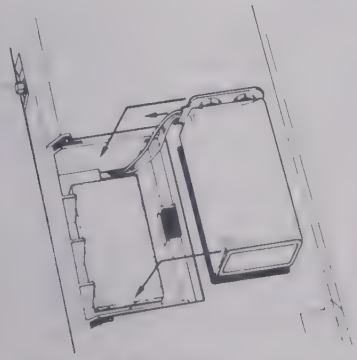


Figure 3. Battery Installation

A 0.75 amp fuse (F101) 3AG, 250V Fast Blow protects the 50mA range. To gain access to the fuse, remove the fuse compartment cover by sliding off in the direction of the arrow located on the fuse cover. Remove the fuse by pulling outward on the plastic tab that encircles the fuse body. Install the plastic tab on the new fuse and snap the fuse back into the holder. Refer to Figure 4.

CAUTION

Do not replace the fuse with a higher rated fuse than specified. Instrument damage may occur.

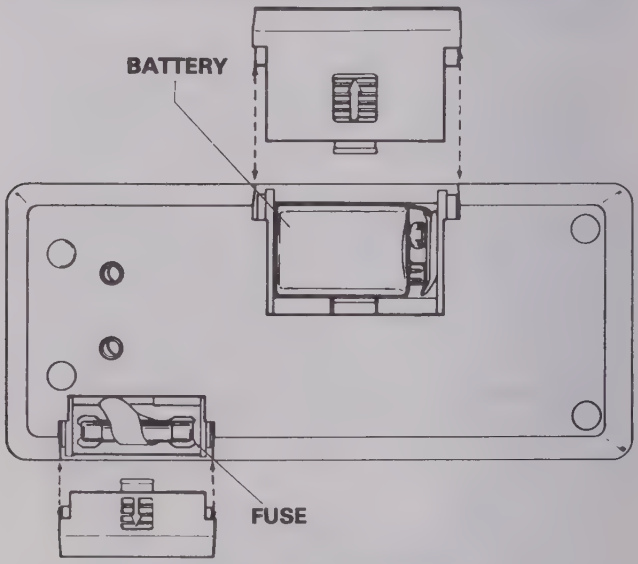


Figure 4. Fuse Replacement

DISASSEMBLY

WARNING

To prevent a shock hazard, remove all test leads from the instrument and turn the instrument off before disassembling the Model 135A.

NOTE

When disassembling the Model 135A handle the PC boards by the edges. Body oil, dirt, etc. can degrade the circuits performance. Keep the PC boards clean and free of contamination.

NOTE

Thick Film network R102 (TF-126) is extremely susceptible to contamination. Clean the circuit boards with

methanol first then distilled water and then blow them dry with dry nitrogen gas.

Place the unit face down and remove the battery. Remove the two #4-40 retaining screws. Grasp the bottom cover and lift gently at the input jack end. Then gently lift the bottom cover away from the PC board. The battery can now be reconnected for troubleshooting and/or calibration. To read the display some light downward pressure at the top end of the A/D board may be required in order to make contact through the strip connecter between the circuit board and the LCD.

To remove the PC board from the top cover, simply separate them from each other. The LCD will remain in the top cover when the PC boards are removed. Be careful that the LCD assembly does not fall out. The switch knobs (31425) and the bushings for the knobs (32419) are also loose in the top cover, be careful they do not fall out of the top cover.

To separate the two PC boards, gently pull the two boards apart at the points where they are connected (at the berg pin connectors).

To reassemble the Model 135A:

1. Reconnect the two PC boards.
2. Install the LCD assembly as shown in Figure 5. Proper allignment of the strip connector is necessary for proper operation.
3. Place the two PC boards into the top cover and place the red switch plate on the power switch. Monitor the strip connector alignment.

WARNING

When reassembling the Model 135A, be sure to replace the on-off switch cover (135-304). Common-mode voltage will be present on the switch, creating a possible hazard if the cover is not replaced.

4. Feed the battery connector through the access opening in the bottom of the battery compartment.
5. Hinge the top and bottom covers together at the display end. Make sure the two catches in the top cover are aligned in the slots in the bottom cover before installing the two #4-40 7/8" screws.
6. Reconnect the battery and reinstall the battery compartment cover.

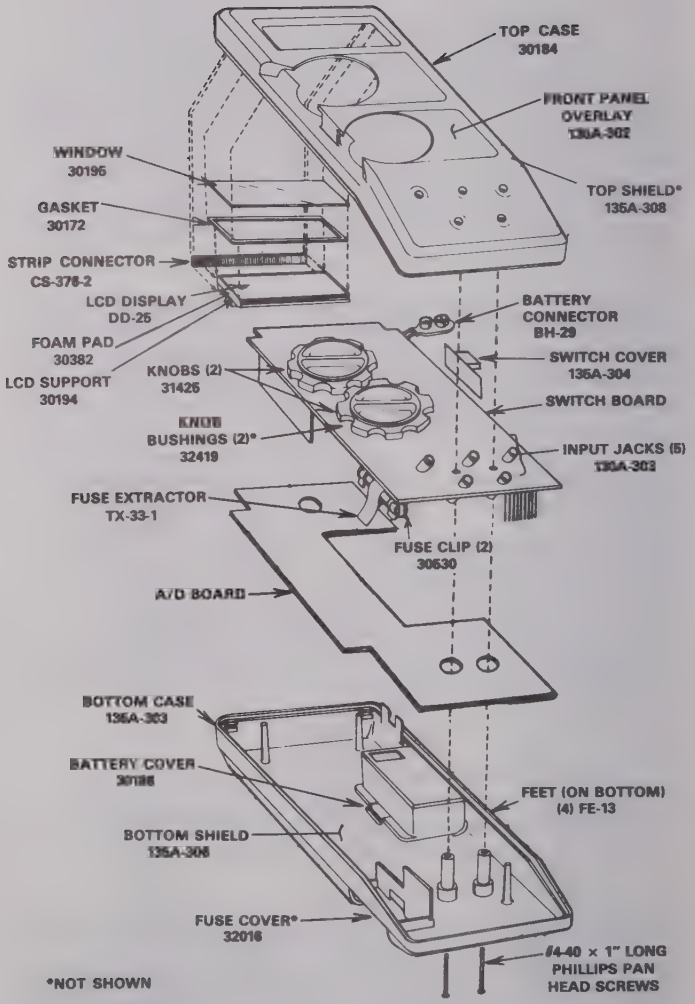


Figure 5. Disassembly

Special Handling of Static Sensitive Devices

MOS devices are designed to function at high impedance levels. Normal static charge can destroy these devices. Table 8 lists all the static sensitive devices of the Model 135A. Steps 1 through 7 provide instruction on how to avoid damaging these devices.

Table 8. Model 135A Static Sensitive Devices

Reference Designation	Keithley Part No.
U104	31847-1
U105, U106	IC-226
U107	IC-326
U201	LSI-41
U202	IC-103
U203	IC-102
U204	IC-138
U205	IC-266
U206	IC-288
U207	IC-287

1. Devices should be handled and transported in protective containers, antistatic tubes or conductive foam.
2. Use a properly grounded work bench and a grounding wristwrap.
3. Handle devices by the body only.
4. PC boards must be grounded to bench while inserting devices.
5. Use antistatic solder suckers.
6. Use grounded tip soldering irons.
7. After devices are soldered or inserted into sockets they are protected and normal handling can resume.

NOTE

The troubleshooting information in this section is intended for use by qualified personnel who have a basic understanding of the analog and digital circuitry used in a precision test instrument. Instructions have been written to assist in isolating the defective circuit. Isolating the defective component has been left up to the troubleshooter.

Table 9. Power Supply and Reference Checks

Step	Item/Component	Required Condition	Remarks
1		Connect a fresh battery to the battery connector and turn the instrument on.	
2	TP1	+5V ±5%	+5V supply
3	TP2	-5V ±5%	-5V supply
4	TP3	+1.0000±.1%	Reference Voltage

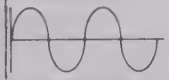
NOTE

Thick Film network R102 (TF-126) is extremely susceptible to contamination. Handle the PC boards by the edge to avoid contaminating them with dirt, body oil, etc. Clean the circuit boards with methanol first then distilled water and then blow them dry with dry nitrogen gas.

Table 10. Ohms Source and Ohms Detector

Step	Item/Component	Required Condition	Remarks
1		Select ohms and place a short across V-Ω and COM.	
2		Remove the shield on the switch board (135A-102-02).	
3	TP4	1.23V nominal	Ohms Source
4	U103A pin 1	-4V to -5V	Ohms detector detecting ohms function (saturated to -5V supply).
5		Select any function other than ohms.	
6	U103A pin 1	+4V to +5V	Ohms detector saturated to +5V supply.

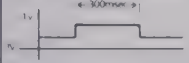
Table 11. AC Signal Conditioning

Step	Item/Component	Required Condition	Remarks
1		Select ACV, 2V range and apply 1V at 500Hz.	
2	TP 10	1V sine wave at 500Hz RMS.	AC Buffer output
3	TP 11*		AC to DC Converter Output

*With 1V rms as the input, the output (TP11) will be

$$\underbrace{(1 \times 1.414)}_{\text{rms to peak}} \quad \underbrace{(1.11)}_{\text{gain}} + \underbrace{.5}_{\text{diode drop}} = 2.07\text{V peak.}$$

Table 12. A/D Converter

Step	Item/Component	Required Condition	Remarks
1		Select DCV and apply 1VDC.	
2	Display	1.0000V	Displayed Voltage
3	TP 5	1.0000V*	Input to A/D
4	TP 8	100kHz TTL level square wave. ±3%	Clock
5	U201 pin 11 (referenced to digital common).	+5V	+5V supply
6	U201 pin 1 (referenced to digital common).	-5V	-5V supply
7	U201 pin 23	+5V	Positive polarity (0V for negative polarity).
8	U201 pin 4	See Figure 6 (page 22)	A/D conversion cycle.
9	TP 7		Reference buffer output.
10	TP 6	Same as TP 7.	

*A 10MΩ load (e.g. DMM) on this TP will cause a -10% error in state condition

Table 13. Display Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power, select any function or range except ohms.	
2	U107 pin 1	+5V ±5%	
3	U107 pin 5	5Vp-p Square Wave	Backplane
4	U107 pins 2-4, 6-26 and 37-40	5V square waves in or out of phase with backplane.	Data to Display
5	U105 pins 2, 6 and 9. U106 pins 2, 6, 9 and 13.	Backplane Waveform	Battery, minus sign and decimal point drivers.
6	U106 pins 1, 5, 8 and 12	Appropriate DP line (high on).	Select all ranges to check all decimal points.

REPLACEABLE PARTS

This section contains replacement parts information, a schematic diagram and component location drawings for the Model 135A. Model 135A.

Ordering Information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering include the following information:

1. Instrument Model Number
2. Instrument Serial Number
3. Part Description
4. Circuit Description
5. Keithley Part Number

Factory Service

If the instrument is to be returned to the factory for service, make a photo copy of the service form which follows this section and return it with the instrument.

Table 14. Replaceable Parts

Circuit Desig.	Description	Schematic Location	Keithley Part No.
BT-101	Battery, 9V		BA-14
C101	Capacitor .02μF, 1000V, 20%, Metalized Polyester	C3	C-285-.02
C102	Capacitor 10μF, 16VDC, 10%, Aluminum Electrolytic	D3	C-321-10
C103	Capacitor 390pF, 1000V, Ceramic Disc	E3	C-64-390p
C104	Capacitor 10pF, 1000V, Ceramic Disc	E3	C-64-10p
C105	Capacitor 10pF, 1000V, Ceramic Disc	E4	C-64-10p
C106	Capacitor .1μF, 50V, Ceramic Film	E4	C-237-.1
C107	Capacitor .1μF, 50V, Ceramic Film		C-237-.1
C108	Capacitor .1μF, 50V, Ceramic Film	D3	C-237-.1
C109	Capacitor .1μF, 50V, Ceramic Film	D3	C-237-.1
C110	Capacitor .01, 50VDC, 10%, Metalized Polypropylene	D1	C-269-.01
C111	Capacitor 1μF, 50V, Ceramic Film	E1	C-237-1
C112	Capacitor 2.2pF, 200V,Ceramic Disc	A1	C-291-2.2p
CR101	Bridge Rectifier	B3	RF-52
CR102	Diode, Diffused, Silicon	C4	RF-28
CR103	Diode, Diffused, Silicon	C4	RF-28
CR104	Diode, Diffused, Silicon	C4	RF-28
CR105	Diode, Diffused, Silicon		RF-28
CR106	Diode, Diffused, Silicon	E6	RF-28
DS101	Display, LCD		DD-25
F101	Fuse, 0.75A, 250V, 3AG	A3	FU-14
J1001	Input Jack	A1	130A-303
J1002	Input Jack	A3	130A-303
J1003	Input Jack	A3	130A-303
J1004	Input Jack	A3	130A-303
J1005	Input Jack	A4	130A-303
J1006	Connector	A5	CS-446-1
J1007	Connector	SEV	CS-446-2
P1006	Connector, Mate for J1006	A5	CS-445-1
P1007	Connector, Mate for J1007	SEV	CS-445-2
Q101	Transistor, Silicon, NPN, GES 5818	D2	TG-138
Q102	Transistor NPN, 2N3904	D1	TG-47
R101	Potentiometer	B1	RP-111-50k
R102	Thick Film Resistor Network	SEV	TF-126
R103	Resistor, 10Ω, 25V, 1% 1/8W, Metal Film		R-179-10
R104	Resistor, .01Ω, 5%, Wirewound Shunt		R-280-.01

Table 14. Replaceable Parts (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
R105	Resistor, 10kΩ, 5%, 1/4W, Composition	D1	R-76-10k
R106	Resistor, 10kΩ, 5%, 1/4W, Composition	D1	R-76-10k
R107	Resistor, 10kΩ, 5%, 1/4W, Composition	E1	R-76-10k
R108	Resistor, 100kΩ, 10%, Composition	C3	R-2-100k
R109	Resistor, 2.2MEG, 10%, 1/4W, Composition		R-76-2.2M
R110	Resistor, Potentiometer	D4	RP-111-200
R111	Resistor, 10kΩ, .1%, 1/8W, Metal Film	D4	R-179-10k
R112	Resistor, 10.65kΩ, 1%, 1/8W, Metal Film	E3	R-179-10.65k
R113	Resistor, 10.65kΩ, 1%, 1/8W, Metal Film	E3	R-179-10.65k
R114	Resistor, 200kΩ, 1%, 1/8W, Metal Film	E3	R-88-200k
R115	Resistor, 200kΩ, 1%, 1/8W, Metal Film	E3	R-88-200k
R116	Resistor, 3.3kΩ, 5%, 1/4W, Composition	E4	R-76-3.3k
R117	Resistor, 470kΩ, 5%, 1/4W, Composition	D4	R-76-470k
R118	Resistor, 470kΩ, 5%, 1/4W, Composition	D4	R-76-470k
R119	Resistor, 470kΩ, 10%, Composition	E2	R-2-470k
R120	Resistor, 470kΩ, 10%, Composition	E2	R-2-470k
R121	Resistor, Thick Film Resistor Network	SEV	TF-129
RT101	PTC Thermister	D2	RT-7
S101	Switch		SW-417
S102	Switch	SEV	SW-432
S103	Switch	C2	SW-439
U101	Low Power FET-Input OP AMP, TL062	B3	IC-279
U102	Linear OP-Amp, 308	E3	IC-99
U103	Dual Low Power JFET Input Operational Amp, LF 422	D4	IC-325
U104	Selected Analog Multiplier (4053)	D1	31847-1
U105	CMOS Quad Exclusive OR Gate, 4070	SEV	IC-226
U106	CMOS Quad Exclusive OR Gate, 4070	G5	IC-226
U107	4-digit CMOS Display Decoder/Driver (LCD), ICM 7211AIPL	G4	IC-326

Table 14. Replaceable Parts List (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
C201	Capacitor 4.7μF, 25V, Aluminum Electrolytic	B5	C-314-4.7
C202	Capacitor 250μF, 25V, Aluminum Electrolytic	C6	C-314-250
C203	Capacitor 47μF, 25V, Aluminum Electrolytic	F3	C-314-47
C204	Capacitor 47μF, 25V, Aluminum Electrolytic	C6	C-314-47
C205	Capacitor 470pF, 1000V, Ceramic Disc	F1	C-64-470p
C206	Capacitor 330pF, 1000V, Ceramic Disc	F1	C-64-330p
C207	Capacitor 1μF, 50V, Metalized Polycarbonate	F2	C-215-1
C208	Capacitor .22μF, 50V, Metalized Polypropylene		C-269-.22
C209	Capacitor .1μF, 50V, Metalized Polypropylene	G2	C-269-.1
C210	Capacitor .047μF, 50V, Metalized Polypropylene	F2	C-269-.047
CR201	CR201 and R201 are a matched set (Selected at factory)	B4	30986
CR202	Diode, Zener	B5	DZ-59
CR203	Diode, Diffused, Silicon	G1	RF-28
J2001	Battery Holder	A4	BH-29
R201	Resistor, R201 and CR201 are a matched set (selected at factory)	B4	
R202	Resistor, Potentiometer	A5	RP-89-200
R203	Resistor, 10k, 250V,.1%, 1/8W, Metal Film	G1	R-179-10k
R204	Resistor, Thick Film Resistor Network	B4	TF-128
R205	Resistor, 1MEG, 10%, 1/4W, Composition	E4	R-76-1M
R206	Resistor, 1MEG, 10%, 1/4W, Composition	G1	R-76-1M
R207	Resistor, 5.1kΩ, 5%, 1/4W, Composition	F1	R-76-5.1k
R208	Resistor, 249k, 1%, 1/8W, Metal Film	G1	R-88-249k
R209	Resistor, 39, 5%, 1/4W, Composition	G1	R-76-39
R210	Resistor, 100kΩ, 5%, 1/4W, Composition	H1	R-76-100k

Table 14. Replaceable Parts (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
U201	4½ Digit Single Chip A/D Converter, ICL 7135	G2	LSI-41
U202	Dual "D" Flip-Flop, 4013	F1	IC-103
U203	Quad 2-Input NAND, 4011	C5	IC-102
U204	Quad 2-Input AND, 4081	F3	IC-138
U205	Quad 2-Input OR, 14071	H3	IC-266
U206	Low Power CMOS OP Amp, ICL 7621	C5	IC-288
U207	CMOS Voltage Converter, ICL 7660	C5	IC-287
Y201	Ceramic Resonator, 200KHz		CR-18

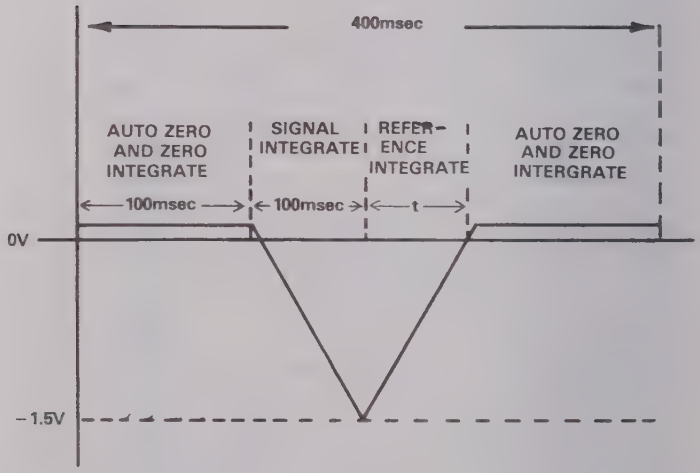
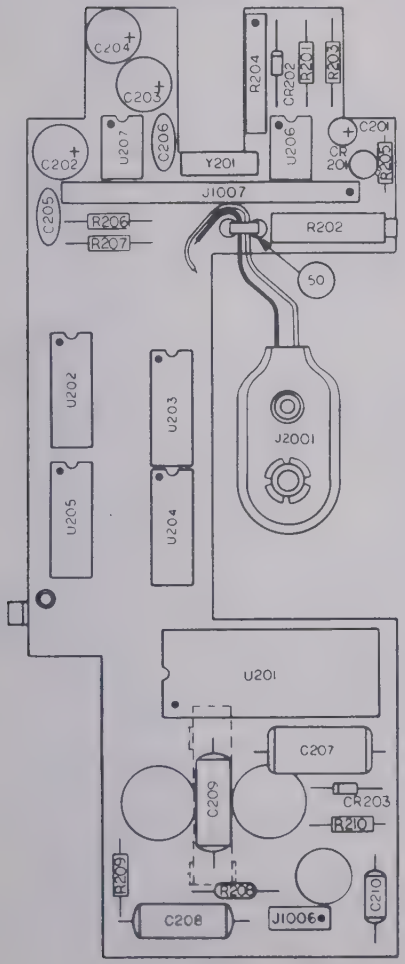
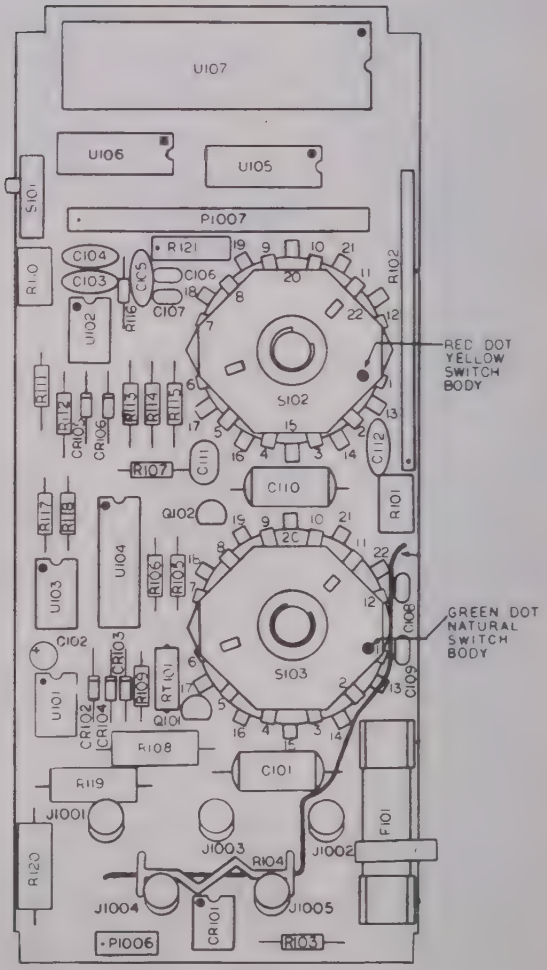


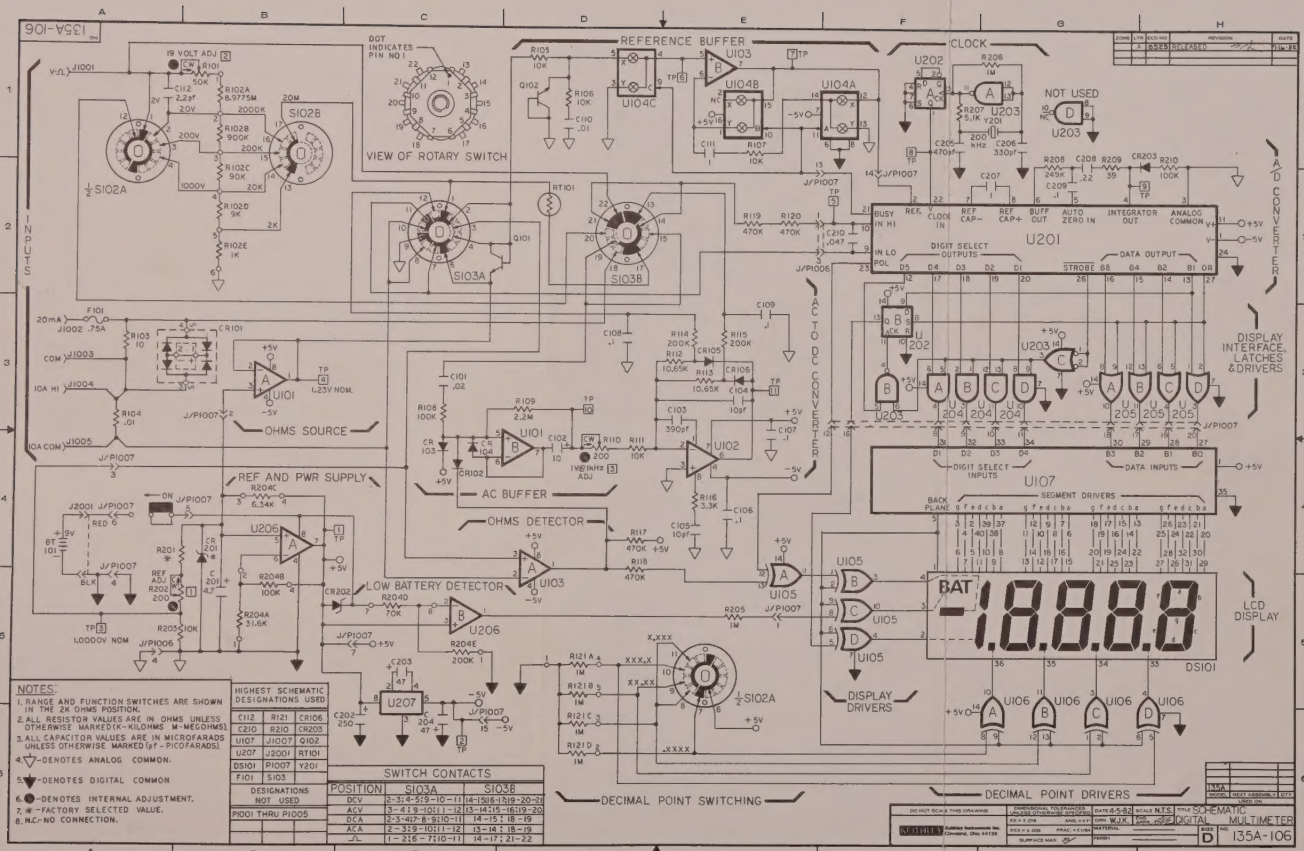
Figure 6. A/D Conversion Cycle

A/D BOARD
COMPONENT LAYOUT



SWITCH BOARD
COMPONENT LAYOUT




135A-106
REFERENCE BUFFER
CLOCK
NOT USED
VIEW OF ROTARY SWITCH
INPUTS
A/D CONVERTER
DISPLAY INTERFACE, LATCHES &DRIVERS
OHMS SOURCE
REF AND PWR SUPPLY
AC BUFFER
OHMS DETECTOR
LOW BATTERY DETECTOR
AUTOZERO SWITCH
DISPLAY DRIVERS
LCD DISPLAY
DECIMAL POINT SWITCHING
DECIMAL POINT DRIVERS
BAT
-1.8.8.8.8
DSI01
NOTES:
1. RANGE AND FUNCTION SWITCHES ARE SHOWN IN THE 2K OHMS POSITION.
2. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED(K-KILOHMS M-MEGOHMS).
3. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED(pf - PICOFARADS).
4. ▽-DENOTES ANALOG COMMON.
5. ▼-DENOTES DIGITAL COMMON
6. ●-DENOTES INTERNAL ADJUSTMENT.
7. ◈-FACTORY SELECTED VALUE.
8. N.C.-NO CONNECTION.
HIGHEST SCHEMATIC DESIGNATIONS USED
C112 R121 CR106
C210 R210 CR203
U107 J1007 Q102
U207 J2001 RT101
DS101 P1007 Y201
F101 S103
DESIGNATIONS NOT USED
P1001 THRU P1005
SWITCH CONTACTS
POSITION S103A S103B
DCV 2-3;4-5;9-10-11 14-15;16-17;19-20-21
ACV 3-4;9-10;11-12 13-14;15-16;19-20
DCA 2-3;4-7;8-9;10-11 14-15;16-19
ACA 2-3;9-10;11-12 13-14;16-19
Ω 1-2;6-7;10-11 14-17;21-22
DO NOT SCALE THIS DRAWING
DIMENSIONAL TOLERANCE UNLESS OTHERWISE SPECIFIED
DRN W.J.K.
TITLE SCHEMATIC DIGITAL MULTIMETER
SIZE D
DWG NO 135A-106

KEITHLEY

SERVICE FORM

Model No. _____ Serial No. _____ P.O. No. _____ Date _____

Name _____ Phone _____

Company _____

Address _____

City _____ State _____ Zip _____

List all control settings and describe problem. _____

_____

_____

_____ (Attach additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.) _____

What power line voltage is used? _____ Variation? _____

Frequency? _____ Ambient Temperature? _____ °F.

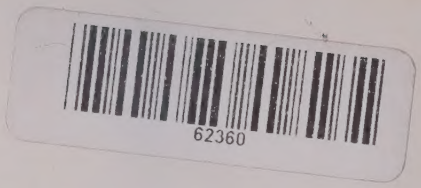
Variation? _____ °F. Rel. Humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe below.)

_____

_____

*Be sure to include your name and phone number on this service form.



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